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Technical Note

The evaluation system of ecological and low-carbon village in Zhejiang Province

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ABSTRACT

This study constructed the evaluation system frame of ecological and low-carbon Village through 6 factors which are plan management, Eco-environment, Infrastructure, economics, energy saving and characteristic appearance in terms of the village attributes in Zhejiang Province . As well as the weight coming from the AHP method, and the judging method with the unity of the subjective and objective, a whole evaluation system has been made. This research chooses 2 different classic villages in Zhejiang Province as a case study and uses the above evaluation system to analyze and evaluate them, which verifies the feasibility of the evaluation system. We hope our study can promote the construction of the ecological and low-carbon Village and give some reference to the village development in Zhejiang Province and even to the whole country.

1. Background

At present, it is the common subject for the world to reduce greenhouse gas, such as CO_2, emissions and slow down the process of global warming. In 2009, the Chinese government revealed the official announcement on the target for controlling greenhouse gas emission and took the green and low-carbon economy as an important content to be listed in the outline of 12th Five-year Plan.

There are more than 48000 towns and 691510 administrative villages in China and the rural areas cover a population of about 674 million, accounting for 50% of the total population. As the rural urbanization increases at a rate of 1% per year, the rural industrial structure, lifestyle, colony architecture and village landscape are hit hard and meanwhile, the carbon emissions in rural areas have also undergone rapid growth. In 2010, the household carbon emission per capita in rural areas is C0.504t, which grew by 196.90 % within the same period compared to 1995 (Liu et al., 2013). Additionally, as the huge system of carbon sink, rural areas have abundant natural resources and ecological environment and thus villages have unique ecological and low-carbon characters compared with the cities.

Therefore, the important tasks for the sustainable development of countryside in 21st century as well as the hot topic of ecological research in rural areas are to optimize and integrate the four systems in rural areas consisting of the natural ecological environment, agricultural activities, industry avocation and colony architecture; coordinate the relationship between the systems; shrink carbon sources; increase carbon sinks; improve the living environment; cultivate consciousness of low carbon development; work out the index system and planning strategy of ecological and low-carbon village.

Frist proposed by Robert Gilman, a Denmark scholar in 1991, the concept of ecovillage is that ecovillage

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identifies human as the standard and combines human activities with the place of residence without damaging the natural environment to support the healthy exploration and utilization of resources, which thus can be developed sustainably to the unknown future. (Gilman, 1991) The research on ecovillage has gained the attention from many scholars all the time. By taking the Bramwich Ecovillage in Hamburg as an example, primary explorations on appropriate technologies of German ecovillages have been carried out, and the reasons of the success for these ecovillages have been summarized (Yue 2011). In Gahna, Mognori Ecovillage was launched in 2007 to build alternative sustainable livelihoods, trust and understanding (Sammy, 2012). The project employs up to 25 locals on a casual basis and features a village tour, canoe safari and home stays, during which visitors enjoy regional cuisine, drumming and dance. In Davis, California, the example of West Village a new ecological neighborhood for 4,200 students, faculty, and staff of the University is presented (Stephen et al., 2012). With its first phase opened in August 2011, the project includes housing, commercial space, recreational facilities, and a new community college center on 130 acres (53 hectares).

In developed countries, there is no obvious difference between the rural and the urban areas due to the high urbanization level and thus in abroad. Therefore, there is no special evaluation index systems for “eco-village”, and besides, such evaluation index systems in abroad take the evaluation system of the ecological green residential area as key reference, such as LEED in the U.S., CASBEE, BREEAM in Britain and so forth (Chen, 2011). But in China, there is a huge gap between the rural and the urban areas and thus the evaluation index system of the urban residential area cannot completely apply to the countryside. Besides, the characteristics and situation in rural China are totally different form the developed countries. As a result, it is necessary to establish the evaluation index system for the rural area.

In recent years, a series of documents related to evaluation index systems of villages in china has been enacted, including Eco-county, Eco-city, Eco-province Construction System (SEPA, 2007), China’s Landscaped Village Assessment Standard enacted in 2009, but there is no index system related to the construction of ecological and low-carbon villages. Combining with regional characteristics, a few scholars proposed the index system of eco-village construction from various perspectives. Combining with the characteristics of the residential area in Huqu Village, in the Construction and Optimization Strategy Research on the Environmental Impact Assessment System in Residential area of Huqu Village, the index system is divided into two parts: the target dwelling environment quality and the target dwelling environment load, which are in total ten factors as the criterion layer of evaluation system. In terms of setting the weights, the empowerment is achieved through expert consultation and AHP method and the weight of evaluation system can be concluded (Zheng 2011). The evaluation index system of the wetland civilization eco-village construction proposed by Liu Yupeng includes five first class indexes, including economic development index, life improvement index, custom civilization index, appearance neatness index and managing democracy index and 26 second class indexes. Besides, after ten experts weighted the 26 indexes, the research selected the optimized index weight by means of the Bayesian Optimization Algorithm (Liu et al., 2011). But so far there is few comprehensive low-carbon evaluation system in rural areas of Zhejiang Province. And most of the above evaluation systems have few case studies.

The research gathered relevant information about the index system and evaluation standard of eco-villages at home and abroad; screened a series of influencing factors and indexes of the ecological and low-carbon village according to the characteristics of villages in Zhejiang province; analyzed its significance and weights. In the meantime, by studying quantitative evaluation method, the research was conducted to form a systematic, quantitative and methodic system and thus form the index system and evaluation standard of the ecological and low-carbon village construction. Finally, 2 different classic villages have been chosen in Zhejiang province as a case study, which verifies the feasibility of the evaluation system.

2. The Establishment of evaluation system

2.1 The setting principle of indexes

2.1.1 The combination of scientific property and operability

The concept of index shall meet the following requirements: it should identify and convey certain connotations; it should measure and reflect the current situation and development tendency of the village environment; it should take the completeness, scientific property and correctness of the theory into consideration. At the same time, indexes should be set based on the existing statistical indexes as much as possible, which are measurable and easy to be quantitative. In other words, by sorting out statistical data, the index data should be easy to be acquired by sampling and typical investigation and the relevant authorities directly in the practical investigation.

2.1.2 The combination of systematic features and characteristics

As an organic whole, the index system can comprehensively reflect and measure the main problems and features of the ecological and living environment systems. In addition, based on the systematic features, the representative comprehensive and main indexes should be selected and characteristic auxiliary indexes should be added for the different regions. But the overlapping and simple listing of the indexes should be avoided. For instance, there are various evaluation rules for different landforms (plains, hills and mountains) and there are also different evaluation rules for various jurisdictions (villages and towns).

2.1.3 The combination of prospective and achievable features

The index system should be set for the outstanding issues of village environment at present and the development tendency of the ecological environment construction in the future. The indexes should be realized within the planning period and meanwhile, the development of social economy should not be ignored. Therefore, the indexes would be predicable and advanced and play a guiding role.

2.2 The framework of index system

According to the difference of levels, the index system in this research can be divided into four levels: general objective level, factor level, index level and detailed regulation level.

As can be seen in Fig. 1, the general objective is to construct the ecological and low-carbon villages. And the factor level includes six parts: plan management, ecological environment, infrastructures, economic industry, low carbon and energy saving and characteristic style. Besides, there are two to four evaluation indexes in each factor and so there are sixteen evaluation indexes in total in six factors. These indexes are screened and merged by the existing rural evaluation system at home and abroad. What's more, each evaluation index has several evaluation detailed rules. There are 44 detailed rules, of which three are controls. If one of the detailed rules cannot be met, the qualification of ecological and low-carbon villages should be canceled.

The scope of the index system covers market towns (central market town and ordinary market town) and villages (central villages and basic villages). And in terms of ecological and low-carbon construction, towns and

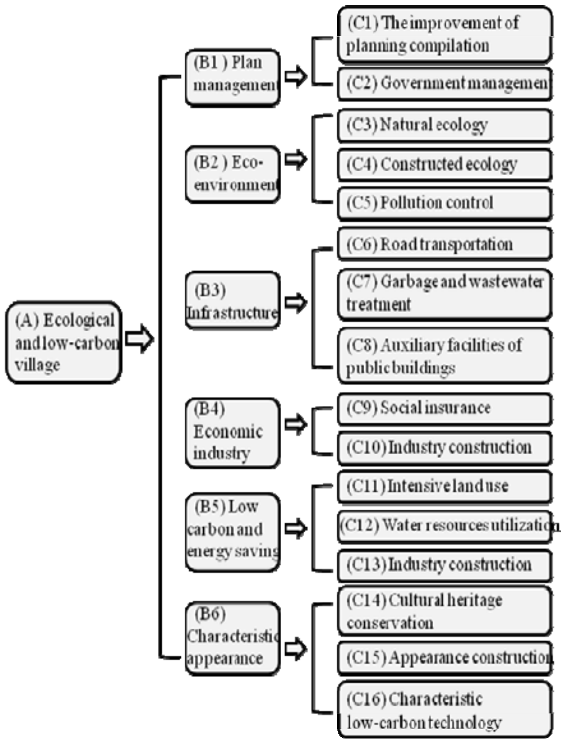

Fig. 1. The Framework of Evaluation System.

villages have different characteristics. At the same time, according to the landforms of villages and towns in Zhejiang Province, the villages and towns can be divided into three parts: plains, hills and basins, mountains. The Plain area is mainly distributed in water network area in Northeastern Zhejiang Plain and coastal areas in Wen-Tai region; hills and basins are mainly distributed in Central Zhejiang Basin, Shengxin Basin, Lishui Basin and so forth; the mountain area is mainly located in the region of Southeastern Zhejiang. What's more, different landforms also have different characteristics in ecological and low-carbon construction.

For differences of towns and villages and different characteristics of different landforms in ecological and low-carbon construction, the index system did the following analysis:

a. Different indexes should be used to evaluate different objects. For example, in the Index C4, constructed ecology, the item of "the public green area per capita" is aimed at towns only, not villages; the item of "the coverage of farmland windbreak" is aimed at plains only, not hills and mountains.

b. The same index should evaluate different objects with specific standards. For instance, in the Index C11, intensive land use, as for the built-up area per capita, the standard for towns is 120 m2 per capita and the standard for villages is 130 m2 per capita. In the Index C3, natural ecology, as for forest coverage, the standard for mountains is 75 %; the standard for hills is 45% and the standard for plains is 10 %.

2.3 The setting of weights

The weight refers to the proportion some index takes of all the evaluation indexes. In the low-carbon evaluation system, each evaluation index exerts different impacts on environment, so different evaluation indexes should be endowed with various weights, which reflects the relative importance between evaluation indexes. In the evaluation system of low-carbon village, the allocation of the weights of evaluation would directly affect the evaluation results. As a result, it is of great importance for improving the evaluating precision and sensitivity to give the reasonable weights of evaluation indexes.

2.3.1 The choice of weight methods

The common weighting methods include regression analysis method, Delphi method, sorting method and AHP method. From the principle point of view, they can be divided into two categories:

a. The regression analysis method is to define the weights according to information features of the sample data, which has excellent reliability and is applicable to the situation, where there are a number of complete samples.

b. The other category includes Delphi method, sorting method and AHP method, which are the knowledge, experience and value judgments based on expert community. Besides, the three methods have low requirements on the number of samples. Among the three methods in the second category, Delphi method is the most difficult because it has high requirements on several aspects, such as the experience and knowledge of experts. And it is difficult for experts to objectively handle the relations between indexes when they give scores. Therefore, in practice, the differential value between indexes is the minimum number. In the Green Building Evaluation Rules, the weights are also evaluated by this method.

When too many indexes exist and experts give scores, the sorting method is easy to be disturbed and thus hard to make sound judgments. Therefore, it is only appropriate under the following circumstances: the number of statistical indexes and samples is small; the statistical results are easy to be controlled; the objectivity and reliability of scoring are easy to be controlled.

The differential weighted values gotten by the AHP method is bigger than any values gotten by the other two methods. The paired comparison method is adopted when it measures the importance of indexes, which is conducive for experts to handle the relations between indexes. In addition, with the mathematical treatment of subjective judgments of experts, the index weights can be calculated by judgment matrix. So this method is more precise and reliable compared to the first two (Wang Jing, 2001).

In the evaluation system of low-carbon village in this research, AHP method, the most precise and feasible method, is selected to determine the weights of factors.

The AHP method (the Analytic Hierarchy Process), proposed by American scholar T.L. Saaty in 1970s, refers to the multi-objective assessment method. The AHP method decomposes the complex problem into few levels, of which each consists of several factors. And then taking the factors in the upper level as a guideline, the AHP method make paired comparison between factors in the next level and then by judgment and calculation, the weight of each factor can be obtained. In general, the measurement scale can be divided into 9 grades, including extremely unimportant 1/9, fully unimportant 1/7, relatively unimportant 1/5, slightly unimportant 1/3, equally important 1/1, slightly important 3/1, relatively important 5/1, fully important 7/1, extremely important 9/1.

2.3.2 Weight determination

From June to July in 2013, 25 experts were invited and the AHP investigation for weight of 16 subprojects in the evaluation system of low-carbon village was conducted. One third of the respondents were from the Planning and Design Institute; one third of them were from government departments, including Planning Bureau, Planning Center and Planning Administration at the grassroots level and one third of them are the professors and scholars specialized in planning. The research results can be seen in Table 1.

In the findings of experts, the consistency check, CR value is far less than 0.1, which demonstrates that the judgment of evaluation indexes is reasonable and the corresponding weights calculated are correct. Through observing the allocation of weights, it can be concluded that in terms of the six aspects of factors, they can be sorted in order of importance: eco-environment, plan management, infrastructure, low carbon and energy saving, characteristic appearance and economics. As for the 16 indexes, experts claimed that planning compilation, government management, natural ecology and pollution treatment are the most important indexes to construct ecological and low-carbon village and by contrast, Auxiliary facilities of public buildings, industry construction and appearance construction are the least important indexes.

Table 1. The calculation results of Index Weights.

Factor	Weight (CR)	Index	Weight
Plan management	0.2457（0.0000）	C1 Planning compilation	0.1303
		C2 Government management	0.1154
Eco-environment	0.2825（0.0015）	C3 Natural ecology	0.1338
		C4 Constructed ecology	0.0533
		C5 Pollution control	0.0954
Infrastructure	0.1501（0.0033）	C6 Road transportation	0.0596
		C7 Garbage and wastewater treatment	0.0654
		C8 Auxiliary facilities of public buildings	0.0251
Economic industry	0.0711（0.0082）	C9 Social insurance	0.0438
		C10 Industry construction	0.0273
Low carbon and energy saving	0.1459（0.0041）	C11Intensive land use	0.0459
		C12 Water resources utilization	0.0479
		C13 Energy utilization	0.0520
Characteristic appearance	0.1047（0.0037）	C14 Cultural heritage conservation	0.0439
		C15 Appearance construction	0.0239
		C16 Characteristic low-carbon technology	0.0369

2.3.3 The Judgment of evaluation results

The hundred percentage point system is adopted in the evaluation system of ecological and low-carbon village in Zhejiang Province. The evaluating basis includes annual statistical reports, document files, public information and results of field survey. Each index is calculated and graded independently by experts.

The full mark of C level index is 5. Different index in the C level has different evaluation rules. For instance, in “C3 natural ecology”, there are rules according to air, water, forests, and noise. If a proportion of forests in one village reaches 70 %, the level of this evaluation rule is rated as level 5.The average score of each evaluation rules is the score of this index in the C level. After the calculation of the scores of all the indexes in the C level by the following formula, the scores are the results graded by the expert. And the average score of total marks graded by all the experts is the final score.

$$A=(0.1303xC1+0.1154xC2+0.1338xC3+0.0533xC4+0.0954xC5+0.0596xC6+0.0654xC7+0.0251xC8+0.0438xC9+0.02731xC10+0.0459xC11+0.0479xC12+0.0520xC13+0.0439xC14+0.0239xC15+0.0369xC16) \times 20 \quad [1]$$

The grade evaluation of the results of final score is listed in Table 2, referring to the National Green Building Evaluation Standard in China. (Ministry of Housing & Urban-Rural Development, 2006).

The ecological and low-carbon village in Zhejiang Province should meet the following criteria: the total score is above 60 and below 70 (including 60) and the controls meet requirements. The ecological and low-carbon village with favorable construction in Zhejiang Province should meet the following criteria: the total score is above 70 and below 80 (including 70) and the controls meet requirements. The ecological and low-carbon village with outstanding construction in Zhejiang Province should meet the following criteria: the total score is above 80 (including 80) and the controls meet requirements.

3. Model study and evaluation

Anji County is one of the advanced villages for ecological construction in Zhejiang Province. There are 244 administrative villages in the county, of which the area covers 98 % of the land and the population accounts for 80 % of the total. Since the start of this century, Anji County has established the development strategy of ecological county. Taking ecological construction as a breakthrough point, the county promotes the ecological construction around the whole county by implementing the town-driving-country policy. This research selected two villages with different sizes in Anji County: Village Y and Village J as the typical case to make analysis and evaluation and meanwhile, the index evaluation system of ecological and low-carbon village can also be validated.

3.1 Basic situations of the two villages

Village Y has a population of 610, and 179 households. With abundant biological resources and favorable environment, Village Y has maintained its natural state, where the air environment quality and water quality has reached Grade I.

Table 2. Grade evaluation of results.

Grade	Pass	Good	Excellent
Score	60-70	70-80	Above 80

Table 3. Basic situations of the two villages.

Village	Population	Area (km^2)	Forest coverage rate	cultivated land (km^2)	income per capita (RMB)	Major Industries
Y	610	4.54	73.3%	0.32	17853	Bamboo and tea
J	2878	14	80%	0.66	15097	

Table 4. The Results of Index Scores in village Y and village J.

Evaluation Criterion	Evaluation Index	Score of village Y	Score of village J
B1 Plan management	C1 Planning compilation	0	4
	C2 Government management	4	5
B2 Eco-environment	C3 Natural ecology	5	5
	C4 Constructed ecology	5	5
	C5 Pollution treatment	5	5
B3 Infrastructure	C6 Road transportation	5	4.3
	C7 Garbage and wastewater treatment	5	4.17
	C8 Auxiliary facilities of public buildings	5	5
B4 Economics	C9 Social insurance	5	5
	C10 Industry construction	4	5
B5 Low carbon and energy saving	C11 Intensive land	3.3	1.7
	C12 Water resource utilization	0	0
	C13 Energy utilization	3.3	3.3
B6 Characteristic appearance	C14 Cultural heritage protection	3	3
	C15 Appearance construction	4	4
	C16 Characteristic low-carbon technology	0	3

Village J is a much larger village in the same Town. And like Village Y, with abundant biological resources and favorable environment, Village J has maintained its natural state. At the meantime, unlike Village Y, Village J is equipped with a set of the perfect integrated management system and a low-carbon village plan.

Both villages located in southwest of Zhangwu Town in Anji County. Basic situations of the two villages are shown in Table 3.

3.2 Evaluation of village Y

In September, 2013, field research was conducted in Village Y of Anji County in Huzhou City in Zhejiang Province. What’s more, the authors make the concrete analysis of the ecological and low-carbon development. The scores of each factor can be seen in Table 4:

In terms of C1 planning compilation and C12 water resources utilization, Village Y got a very low score. Especially the aspect of planning compilation, the original general planning is not very practical and the new general planning is still in the stage of design. Besides, the construction scheme about ecology and low carbon is still lacked. In the aspect of water resource utilization, there are no special measures for water saving and rainwater collections.

In the aspects of C3 natural ecology, C4 constructed ecology, C5 pollution treatment, C6 road transportation, C7 garbage and wastewater treatment, C9 social insurance and C11 intensive land, Village Y got rather high scores. Especially in terms of eco-environment, Village Y has excellent performance mainly because Village Y has inherent advantages in natural environment and the local government and villagers attach great importance to the protection of ecological environment. And what is worth learning is that the Village Y carries out the pilot program in Longtingwu and implemented the campaign of the classified garbage recovery all over the village. Due to the good work of propaganda and education in the early stage, villagers can classify the garbage consciously, which can be completed perfectly.

At last, the scores of each index can be calculated by the formula. And the total score of ecological and low-carbon evaluation of Village Y is 70.06. Since the total score is above 70 and below 80 (including 70) and the controls meet requirements, Village Y can be regarded as the ecological and low-carbon village with favorable construction in Zhejiang Province.

3.3 Evaluation of village J

In September, 2013, field research was conducted in Village J of Anji County. What’s more, the authors make the concrete analysis of the ecological and low-carbon development. The scores of each factor can be seen in Table 4:

In the aspects of C11 intensive land, C12 water resources utilization, Village J got low scores. Especially in terms of water resources utilization, the area of the concentrated government office buildings, namely, office buildings of village committee is fairly large and the area per capita is 28 m^2, exceeding the maximum standard (18 m^2) of the building area of the party and government

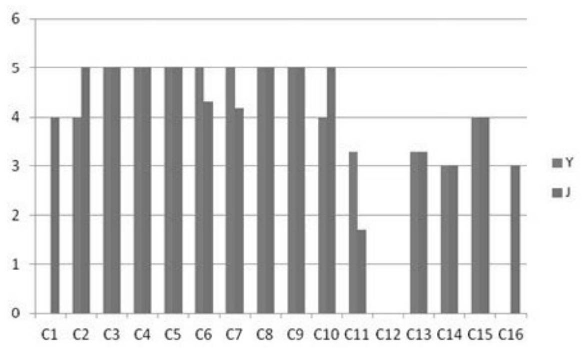

Fig. 2. the Comparison of Index Evaluation Results.

office buildings below the administrative levels of county and town regulated by Notification of State Development and Planning Commission on the Construction Standard of the Party and Government Office Buildings (Investment[1999]No. 2250). The built-up area per capita is 156.4 m^2, which also exceeds the maximum standard of 130 m^2. In the aspect of water resource utilization, there are no special measures for water saving and rainwater collections.

In the aspects of C3 natural ecology, C4 constructed ecology, C5 pollution treatment, C6 road transportation, C7 garbage and wastewater treatment, C9 social insurance and C10 industry construction, Village J got high scores. Especially in the aspect of industry construction, Village J combines a good ecological environment, organic green crops with rural eco-tourism to form a virtuous ecological industry chain, which not only brings many benefits to villagers, but protects the ecological environment.

At last, the scores of each index can be calculated by the formula. And the total score of ecological and low-carbon evaluation of Village J is 82.17. Since the total score is above 80 (including 80) and the controls meet requirements, Village J can be regarded as the ecological and low-carbon village with excellent construction in Zhejiang Province.

3.4 The comparison of evaluation results

The evaluation results are basically consistent with the facts of the two villages. Figure 2 compared the evaluation results of each index between Village Y and Village J. Among 16 evaluation indexes, the scores of 9 indexes in Village Y and Village J are the same. The 9 indexes are mainly distributed in B2 ecological environment and B6 characteristic appearance, which are related to the close geographical distance between two villages.

In the rest indexes, Village J has 4 indexes including C1 planning compilation, C2 government management, C10 low-carbon industry construction and C16 characteristic low-carbon technology, of which the values are higher than Village Y. And this phenomenon fully embodies the efforts and achievements of the local government and villagers on low carbon and energy saving, for instance, experts were invited to plan and design the low-carbon village in 2013. Besides, the low-carbon and energy-saving construction of the farmhouse and the right positioning of ecotourism industry are also the examples. Comparatively speaking, Village Y has 3 indexes including C6 road transportation, C7 garbage and wastewater treatment and C11 intensive land, of which the values are higher than Village J. And this phenomenon embodies the efforts and achievements of the local government and villagers on the infrastructure construction. In particular, the garbage sorting measure, which many cities in China failed to accomplish, can be implemented in Village Y.

4. Conclusions

For the village attributes in Zhejiang Province, this study is conducted to construct the evaluation system framework of ecological and low-carbon Village through 6 factors including plan management, eco-environment, infrastructure, economics, energy saving and characteristic appearance. And by the AHP method, the weight of each index is calculated and the judging method of the combination of the subjective and objective analysis can be selected. Therefore, the complete evaluation system of ecological and low-carbon village had been established. In addition, the research chooses 2 classic villages of Anji County in Zhejiang Province as case study and makes analysis and evaluation according to the evaluation system. And the results are consistent with low-carbon and ecological situation in the village, which proves the feasibility of this evaluation system.

There is some limitation of this study, for instance, the author applied the system to only one area which can't stand for the whole province. So in the next phase of research, more villages with different types will be selected for case study and the characteristics of different villages can be analyzed so as to perfect the evaluation system in this research.

With the lack of practice and research of ecological and low-carbon village construction in current China, it is great honor to promote the construction of the ecological and low-carbon village and give the systematic guideline and framework to the village construction and development in Zhejiang Province and even to the whole country. The ecological and low-carbon concept can be turned into the specific index system and evaluation criteria so as to put the concept of ecology and low carbon into practice.

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